A Study on High Efficiency Wing-vane Compressor
- Part 1: A Simulation Analysis of Dynamic Model -

Raito KAWAMURA\textsuperscript{1*}, Shin SEKIYA\textsuperscript{2},
Tatsuya SASAKI\textsuperscript{3}, Hideaki MAEYAMA\textsuperscript{4},
Shinichi TAKAHASHI\textsuperscript{5}, Kanichiro SUGIURA\textsuperscript{6}

\textsuperscript{1, 2, 3} Mitsubishi Electric Corporation, Advanced Technology R&D Center,
\textsuperscript{4} Mitsubishi Electric Corporation, Living Environment Systems Laboratory,
\textsuperscript{5, 6} Mitsubishi Electric Corporation, Shizuoka Works,

23\textsuperscript{rd} International Compressor Engineering Conference at Purdue
© Mitsubishi Electric Corporation
We introduce the new type compressor “Wing-vane compressor” with 3 parts as follows,

Part 1: 
*A Simulation Analysis of Dynamic Model*

Part 2: 
*Lubrication Characteristic of The Partial Arc Guide Bearing*

Part 3: 
*Experimental Evaluation of The Prototype*
Part 1: A Simulation Analysis of Dynamic Model

CONTENTS

1. INTRODUCTION

2. BASIC STRUCTURE OF WING-VANE COMPRESSOR

3. OPERATING PRINCIPLE

4. CHARACTERIZATION

5. CONCLUSIONS
1. INTRODUCTION

Air-conditioning and cooling systems

Package Air Conditioner & Multi Systems

Room Air Conditioner

Refrigerant

HFC (Hydro fluorocarbon)

- Mainly used as refrigerant
- Affect global warming

To prevent global warming

- Need to develop technologies for the use of low GWP refrigerants

Problem

Compared with R410A, R1234yf has a low density. Larger sizes are required in compressor

Developed "Wing-Vane Compressor" To prevent an increase in size without performance degradation.

- R410A
  GWP: 2090

- R32
  GWP: 675

- R1234yf
  GWP: 1
2. BASIC STRUCTURE

- The compression mechanism is composed of a frame, cylinder, cylinder-head, rotor, shaft, four bushes, and two wing-vanes.
- The wing-vane is composed of one vane and two vane-guides.
- The vane-guides are fitted into the groove in the frame and the cylinder-head.

Fig.1 Basic structure of wing-vane compressor
2. BASIC STRUCTURE

- The tip of vane does not contact with the cylinder inside.
- The wing-vane compressor can achieve a high efficiency and small size using this structure.

![Fig.2 Horizontal cross-sectional view of compression mechanisms](image)
3. OPERATING PRINCIPLE

- The vane rotates around the center of the cylinder.
- It is possible to keep the gap between the vane tip and the cylinder.

Fig.3 Compression process of the wing-vane compressor
3. OPERATING PRINCIPLE

ウイングベーン圧縮機の構造

Animation of operating principle
4. CHARACTERIZATION

(1) Compression chamber volume change

![Diagram showing volume change in compression chamber]

\[ S_1 = A(\theta) \]
\[ S_2 = A(\theta + \pi) - A(\theta) \]
\[ S_3 = \pi(a^2 - b^2) - A(\theta + \pi) \]

\[ A(\theta) = \frac{a^2 \phi}{2} - \frac{b^2 \phi}{2} - \frac{be \sin(\phi)}{2} \]

**Fig.4** Calculation model of volume change in compression chamber

**Fig.5** Characteristics with respect to rotation angle
4. CHARACTERIZATION

(2) Torque and rotor load

Fig. 6 Calculation model of the torque and the rotor load characteristics

\[ T_r = F_{p1} \left( a - \frac{L(\theta)}{2} - e \cos(\phi) \right) + F_{p2} \left( a - \frac{L(\theta + \pi)}{2} - e \cos(\phi + \pi) \right) \]

\[ F_r = \sqrt{\left(F_{ex} + F_{sx}\right)^2 + \left(F_{ey} + F_{sy}\right)^2} \]

Fig. 7 Characteristics with respect to rotation angle

*calculated under specific operating conditions
(Evaporation temperature 52°C, Condensation temperature 5°C)
4. CHARACTERIZATION

(3) Vane load

\[ F_p : \text{Load applied on the vane from the pressure difference (side)}, \]
\[ F_b : \text{Load applied on the vane from the pressure difference (back/ tip)}, \]
\[ F_s : \text{Load applied on the bush,} \]
\[ F_{cv} : \text{Centrifugal force applied on the vane,} \]
\[ F_{ca} : \text{Centrifugal force applied on the vane-guide,} \]

\[
F_1 = \frac{2F_{ca} + (F_b + F_{ca})\cos(\zeta) + (F_s - F_p)\sin(\zeta)\sin(\alpha / 2) + (F_s - F_p)\cos(\zeta) - (F_b + F_{cv})\sin(\zeta)\cos(\alpha / 2)}{2\sin(\alpha)}
\]

\[
F_2 = \frac{2F_{ca} + (F_b + F_{ca})\cos(\zeta) + (F_s - F_p)\sin(\zeta)\sin(\alpha / 2) - (F_s - F_p)\cos(\zeta) - (F_b + F_{cv})\sin(\zeta)\cos(\alpha / 2)}{2\sin(\alpha)}
\]

**Fig.8** Calculation model of the stability of the vane-guide

*Under specific operating conditions (evaporation temperature 52°C, condensation temperature 5°C)*

**Fig.9** Characteristics with respect to rotation angle
5. CONCLUSIONS

■ A new “wing-vane compressor” which has no contact between the vane and cylinder has been developed to prevent an increase in size without performance degradation.

■ The characteristics of the compression process, torque, and rotor load, are almost the same as the sliding-vane type.

■ Lubrication of the newly added vane-guide is important to ensure reliability.

Next Presentation

Part 2:

_Lubrication Characteristic of The Partial Arc Guide Bearing_